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ABSTRACT

Sociology will more meaningfully address social change within the private sector if it considers the relationship between business planning and the constraints which operate on industry in the sphere of technology implementation. Specifically, sociologists should incorporate realities of business planning into industry-related models if sociology is to meaningfully address social change within the private sector. The debate between technological advancement and environmental protection serves as a good example of a case in which social science research can provide information and help effect compromise on social problems. When business/industrial managers recommend a course of action or offer a specific technology forecast, they do not normally even when environmental concerns are involved--seek advice from social scientists. They do, however, consider many factors such as the size and financial resources of the organization, social reactions to the development, impact of the technology on internal company functioning, future prospects, and the ability of the organization to meet the technologically derived demands. Sociologists can help management make more sophisticated plans by offering to focus their research techniques on additional factors such as needs, demands, resources, regulations, values, trade-offs between technological development and environment, public education needs, and the relation of profit maximization to social needs. (DB)

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ENVIRONMENT AND TECHNOLOGY IN SOCIOLOGICAL PERSPECTIVE *

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ABSTRACT

ENVIRONMENT AND TECHNOLOGY IN SOCIOLOGICAL PERSPECTIVE

by

Adrian R. Tiemann

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The environment/technology debate is a new version of the nature/artifice issue and demonstrates how technology is embedded in a variety of social factors, each of which serve as nodes of risk generation. Technology is science applied to human needs, and hence the links between it and those social factors represent risk potentials which must be evaluated in making trade-offs between enjoying technology's benefits and minimizing environmental harm. A variety of constraints operate on industry in the sphere of technology implementation which social critics fail to take into account. These realities of business planning need to be incorporated into models of corporate functioning if sociology is to meaningfully address social change within the private sector. Using examples from the high technology versus environmental reform debate, a model is advanced a) to distinguish between the probable social impacts of technologies at different levels of complexity, and b) to suggest implications for social policy.

The very old division between nature and artifice [1] which has seeded philosophic and religious argument since time immemorial, has emerged anew in the ecological debate pitting environment against technnology. It is not surprising that this social reform movement should have received initial impetus in the United States, formed as it was during a revival of philosophical primitivism during the 17th and 18th centuries, [2] in which the "goodness" of nature was everywhere evident in a bountiful and apparently limitless land. Nor is it surprising that the debate should be particularly heated here, too, for also from the beginning of nationhood, the theme of progress served as a powerful metaphor feeding the expectations of increasing hordes of immigrants. The country's path to the twentieth century was predictably a series of thrusts and counterthrusts between exponents of these dominating world-views, the basic arguments being expressed first in one form and then in another. [3]

This series of alternations in public attitudes was different from the most recent cycling which emerged with the environmental movement in the 1970's however, in that protest had not only become politicized but professionalized. [4] While support for the cause may have come from a wide spectrum of society, its leaders were intelligent and educated, politically wise and often, scientifically sophisticated. Both the terms of the debate and the requirements for compromise were ratcheted up several notches.

In this context of the historical roots of the nature versus artifice debate epitomized in environmentalism, and its recent transformation into a serious force in policy making, I would like to consider some constraints on technology implementation from an industrial point of view which need more attention. The environmental critique cannot remain a force in decision making unless it broadens its perspective, and to help it do so, let us consider the matrix within which technology is embedded.

Technology as science applied to resources exists in a social matrix and becomes relevant only when it is adopted by and adapted to a society for a social purpose. Hence technological change in and of itself, that is, divorced from its social context, has traditionally been seen as a danger requiring regulation within a value context. 5/ As Nef 6/ points out (1977, p. 140):

> "In medieval times, mining was looked on with disfavor. It was often regarded as robbery, even as a kind of rape. Unlike the plow, which made the earth fertile, the pick and shovel removed what seemed to be irreplaceable soil and subsoil."

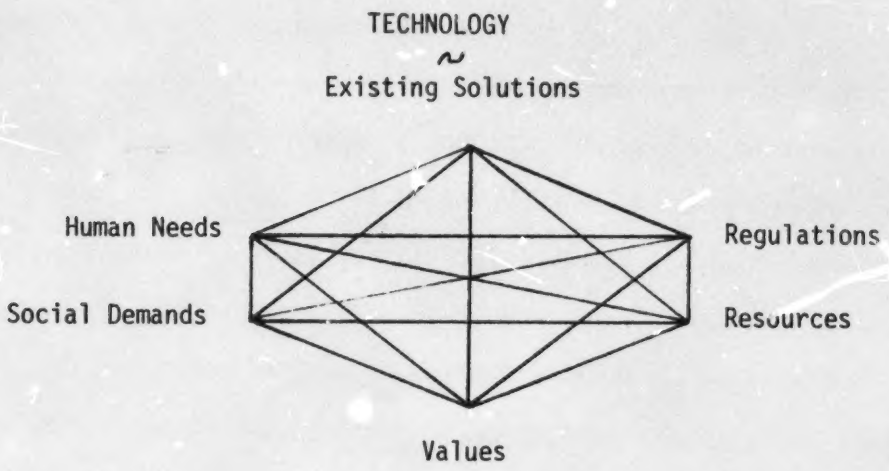
As human needs changed, so did values, and a different attitude emerged, as expressed in Agricola's DE RE METALLICA (1556) that the miner's task

> "was more honorable than that of merchants trading for lucre." (Nef, op. cit.)

Technological development, then, has always taken place against just such a background of a community's anticipated needs or demands, in the context of existing solutions to these desiderata, regulatory

constraints and competing values, and against a fund of perceived resources. [7] Implicit in the process are a number of points at which risks are generated and evaluated. In a sense, these risks and strategies for their management, constitute a set of demands that can be made upon societies [8] in the name of technology although their genesis may equally well be said to lie elsewhere.

Let me present an incomplete model of how risks are generated in society with reference to technological solutions. You will all recognize that the variables enumerated are not as independent as they appear for presentation purposes, and that interconnections between them may have substantial implications for policy. I'd like to draw your attention to the lines between these variables which represent risk potentials, as the variables themselves represent nodes of risk generation. In this model, as you can see, there are substantial risks not relating to technology at all. However, in this discussion let us focus on the lines converging upon technology.



Basic human needs for food, clothing and shelter (and probably mobility must be counted here, too) can probably be satisfied in minimal fashion without substantially lowering the lifespan, as demonstrated in a number of aboriginal societies. 9/ There can be, in other words, a congruence between existing, possibly very low-level, solutions and existing societal needs. Additional risk arises, then, when a change in any parameter is contemplated. (For all solutions, however primeval, entail risks.) What effect will changing the existing solution to providing human needs have upon the society? And, can present-day sages "see" the future well enough to help us formulate policy regarding these changes? How might an ancient civilization have performed a technology evaluation of the wheel and would it have outlawed its use on the basis of the new dangers that it posed society? On the other hand, might this ancient civilization have done what it could to promote the technology through wider dissemination, specific resource grants of experts and materials, allocations for "research" into superior designs, and the like, perhaps with demonstration programs for the wary? One may laugh at these appelations in this context, but Washingtonese is just an update on a very old process that has occurred throughout the millenia.

Demands, on the other hand, are derivatives of ever-changing values, solutions and resources. To the extent they differ from basic needs and influence them, they create the instability which issues forth in calls for "progress" or "development." Demands are the social component in risk generation.

Regulations are objectifications of past problems with solutions, in the sense that they are reaction mechanisms deeply affected by social values, human needs and demands, and existing technology. Regulations are the political component in risk generation and evaluation, especially as applied to technology.

Resources are, in addition to being physical entities, objectifications of knowledge and ideas embodying purposes. 10/ A particular botanical plant may embody a number of different functions depending upon its social definition. It may be a Shaman's medicine, or a culture's foodstock, or high science's wonder material. Thomas Edison turned a close cousin of that ragweed from which many of us suffer today into synthetic rubber. In future times we may come to look upon this garden weed as a cherished resource. (Some would say that people are our most important resource.) Hence resources are as intimately tied in with values as they are with technology, and like them, generate risk in the process of changing, as when resources evolve into new embodiments of purposes, or a shift in the composition of the workforce occurs.

Values are paradoxically, disproportionate generators of risk at the same time they function to contain it. They perform this dual role by acting largely to solidify old risks as against new ones, foregoing future benefits against known costs. Perhaps no better illustration of the role of values as conservers exists than humanity's historical reluctance to adopt new ways. 11/ Values may also overtly promote risk-taking.

Finally, technology both generates risks all along its cycle of development, implementation and growth, and acts to contain other risks.

For example, the number of horseback riding accidents has markedly declined since we switched to automobiles while the number of fatalities ascribable to tobacco usage has skyrocketed since technological automation of its manufacture and mass advertising made its use widespread.

Needs, demands, resources, regulations and values are thus key elements in assessing trade-offs between environment and technology by virtue of their individual contributions to risk generation. Recognition of aspects of this fact has been implicit in many environmental critiques of society calling for moral reform, in which new forms of social organization and alteration in our value structure have been called for. 12/ The demand that management consider "externalities" can be viewed as a demand for public control in the face of widespread value flux. Were values more secure, management would "know" what to do and the public would agree with its determination. Concomitantly, management's lack of clear responsibility and the public's assumption of an increasing share, heightens the accountability problem in this shift from a tribal elder management system to one based on publicity.

This brings us to a more detailed consideration of the constraints operating upon industry when it performs a technology forecast or evaluation of a new product line and embarks upon a new product endeavor. Important among these are the size and financial resources of the organization, its environmental complexity, the impact the decision to proceed with the technology will have upon its internal functioning and future prospects, (especially in terms of how rapidly technological change itself is occurring) and the societal and organizational infrastructures

available to industry to meet the technologically-derived demands. The development of some technologies has been so slow as to make planning for the future virtually unnecessary. The modern chronometer has, according to E. F. Carter, [14] the following history:

1276 falling mercury clock

c. 1250 first drawing of escapement principle; weight driven mechanism in use

1641 Galileo applied pendulum to clock

1676 Rack striking mechanism invented

1735 first clock with hand-cut gears

1847 electric clock invented

1898 "synchronome" principle; pendulum driving electric slave clocks

1946 atomic clock

Electronics represents an example at the opposite end of this spectrum. [15] Both demonstrate that what we "know" about "supplies" and "demands" using existing data, are very primitive approximations of the future. Thus, when industry strives to rationalize its future, (which constraint affects it more seriously than it does any other sector of society) it is operating in a vast field of uncertainty. As Denis Gabor [16] has pointed out, planning consists of continuously searching for and modifying goals in a non-deterministic framework. In many cases, decisions are a function of constraints rather than a function of the relative benefits of available choices. [17]

For example, industry in 1945 was far less enthusiastic than the media about developing applications of atomic power. While journalists were rhapsodizing over irradiated foods that would never have to be refrigerated, electricity too cheap to meter, and a cancer cure just around the corner, GE's president Charles Wilson was expressing extreme caution. In addition to technical problems to be solved, he said

> "Only time will tell whether future developments will permit atomic energy to be made available at costs which will allow its general commercial use." 18/

Generating equipment manufacturers did not enter the nuclear business on the basis of its overwhelming economic appeal, or even on the basis of its technological superiority. They entered it largely as a result of a governmental invitation they could not afford to refuse. When Eisenhower announced the "Atoms for Peace" program in December 1953, it was done not for reasons of "economic or technological necessity, but for considerations of national prestige and foreign policy." 19/ The government exerted strong pressures on industry to respond to the call for peaceful uses of atomic power, once it relinquished its national security stance of the late 1940's and early 1950's (subjecting nuclear power generation to security barriers, classifying atomic energy technology as secret, etc.). In January 1955 the AEC announced its Power Reactor Demonstration Program, to provide assistance to manufacturers. Fuel use charges (fuel was government-owned) would be foregone for 7 years, some R&D work would be performed at government labs without charge, and R&D aspects of post-construction operations would be subsidized. To

emphasize the importance it placed on this development, Phases 1 and 2 of this project were telescoped so that Phase 3 was begun only two years later, in January of 1957 (although the program did extend over 15 years).

Not unexpectedly, the government paid inadequate attention to institutional factors in this speed up. Not all utility companies were alike, nor could all equally easily support high cost/high risk technology. Companies without the financial resources and the stability of industry giants were hard put to compete successfully. Indeed, one vendor in this field sought market penetration virtually on the basis of a one-man operation. I knew him, and he was the one man in their outfit who knew something about nuclear reactors. His company was so enamoured of the potential offered by this new technology that they put him in charge of a thirty-man engineering team. That company's declining fortunes may be dated from the time it decided to participate -- not because my friend was inept, but because the company had insufficient infrastructure resources. While such problems are usually associated with developing nations, they occur here, too. 20/

Lack of technical infrastructure plagued not only vendors, but operators and overseers alike. With their old plants and their conventional technology, utilities had little need for recently trained engineers. Old-timers were used to a utility world containing little risk, predictable load-growth and proven solutions. Only as nuclear power grew did utilities seek the services of skilled personnel and give them managerial authority, and hence only with experience could nuclear knowledge be integrated over the organizational structure. 21/

The disjunction between the world view and managerial ethos of the old-line engineers and the needs of the new technology as it began to be implemented contributed no little to the difficulties nuclear power encountered. [22] For example, the assumption that the non-generating components in a nuclear plant were comparable to those of other power sources, was incorrect. The habit patterns and attitudes of operators and engineers were inappropriate to managing this new design, and early problems encountered demonstrated how essential it was to take nuclear plants on their own terms, rather than by trying to cast them into an outdated mold. It's not that the operatives, either then or now, had to be "automata" as Jungk [23] complains. But they did have to be aware of critical differences between the old and new plants, and take these into account in daily operation and maintenance activities. As we have seen at Three Mile Island, the focus on improbable but serious accidents claimed an inordinate amount of engineering and regulatory attention when the more mundane daily problems were likelier to be the culprits. [24] This focus was probably a natural outcome of the newness of nuclear technology, for it is always easier to make incremental changes.

Unfortunately, there were few places engineers and operatives could go to acquire the necessary training for dealing with nuclear plants. For some years after the government initiated its Power Reactor Development Program, a "final" design had not been settled on. The technology was in the process of being invented while it was being developed. Some companies had been vendors to the government during the war years and had skilled staff members. These companies had investments in the

technology they had developed during those years. But the government wanted to establish a "best" technology out of the many possibilities that appeared on the scene, few of which had been reasonably well explored. This essentially research-oriented project was carried out within the context of the competitive marketplace, in which when the chips fell where they might, one company might be down and out. The government mandated that nuclear power development should proceed and it set the timetables for the stages. Despite the uncertainties involved in developing a new technology, many companies reasoned that with such official momentum behind their efforts, they would be protected. In any event, vendors had to think twice about the effects their refusal might have on this prime customer in terms of other contracts, or orders already or likely to be placed. Because of the government's various support services alluded to earlier and the enactment of the Price Anderson indemnity act, vendors obtained a false sense of security from their not-so-silent-or-invisible partner, little realizing how effectively and how soon public interest groups could override this mandate.

In this heady climate of government sponsorship, participants lost sight of the necessity to retain flexibility in the relation between the public and its experts, to avoid

> "'officially' sanctioned expertise and other forms of rigidity that hinder the flow of observations and analyses and that may lead too quickly to a consensus in which values and underlying assumptions remain unquestioned." 25/

This was the same problem that had arisen earlier. Scientists most qualified to advise government were most deeply involved in the project, 26/ and the scientific community as a whole lost control over its work.

Despite these official efforts, industry still faced sizeable reluctance from utilities themselves, who showed a substantial and, in the context of existing energy prices, a reasonable unwillingness to undertake such a risky venture as nuclear construction. Given the security feelings referred to above, industry therefore sought a mechanism that would override the utilities' concerns regarding the operational feasibility of this new technology. That mechanism was the "turnkey" plant, in which all the utility would have to do was to "turn the key" and power would start to flow through the lines. The corporation was forced, in effect, by government inattention to important institutional factors existing in society at the time, to devise a scheme that would mitigate them -- and at its own expense. Turnkey plants would be "educational" and demonstrate the viability of the technology. 27/ Industry hoped to spin off some benefits from this loss leader procedure in the form of building sibling plants, but this did not occur and overall, industry sustained losses that have been estimated to run from $875 million to $1 billion. 28/

During this period of heavy government promotion and industry compliance, another critical constraint was operating: intelligent opposition. 29/ Now, I do not mean the sort of opposition that Nader's group represents; that is intelligent, too. But I refer specifically to a competitor's actions taken in response to perceived developments in the originating company's efforts. Remember, the hope had been expressed from the beginning that nuclear power would prove less costly than conventional sources and would provide an escape from the resource

trap into which we seemed to be headed. As the time approached when nuclear might have a chance of substantiating this hope, the coal industry, not amenable to assisting in its own demise, reacted with deep reductions in the price of coal. 30/ For example, Jersey Central Power & Light had been paying 31¢ per million Btu's for delivered coal. When it began negotiating for a nuclear facility, the price was dropped to 26¢. The coal sector's actions thus increased the pressure on the budding technology of nuclear power generation.

The other side of the professional information problem -- the infrastructure trap -- is the public education problem. 31/ During the 1950's there was a failure on all sides to address this issue in meaningful terms. The government appears to have assumed that the public would respond as eagerly to developments in the nuclear field as they had to the substitution of oil and natural gas for coal. A few hortatory publications and films were all that would be necessary, it seemed. They ignored the immediate and intelligent questioning of natural purpose posed by the new technology. For example, the day the news broke, James Reston commented:

> "The atomic bomb...has startled Washington into a realization of the magnitudes of the problem of victory at home and abroad. ...Men...have glimpsed the future of America. Before they had wholly synchronized our political and economic institutions with the age of steam, and while they were arguing over the urgencies of the age of air, they were suddenly confronted with the shadow shapes of the age of the atom.
>
> What are they wondering about? Well, they are wondering about a great many things they have taken for granted for a very long time. ...They are wondering what happens to the old theories about States' rights and labor's rights and management's rights and the farmer's

> rights in the atomic age...How are men to be employed in an era of atomic power when we could not even employ them in an age of electricity?...How are men who are full of prejudice and fear and selfish national desires to live together in a world that has atomic bombs but that has no generally accepted rule of law?"

and Zorbaugh gave utterance to the complaints that were to well up in the 1970's:

> "The problem we face is this: During the years we must wait for science to harness atomic energy in the interests of civilization, can we prevent atomic energy from destroying civilization?... Faced with a future that might at any moment disintegrate in a series of atomic explosions, how long would men cling to the long range values and goals around which, surely if haltingly, we have built our civilization? Living with so drastically uncertain a future must profoundly change man's psychological and social outlook -- cause man to live for the present rather than the future, for himself rather than the community. No government could afford to let control of atomic energy out of its hands. Holding it, the power of government would inevitably be heightened and centralized. With nations viewing each other over rocket-trajectories...knowing that survival depends upon beating their opponents to the draw, how long would what is left of international morality stand up?...
>
> There were physicists who predicted that the splitting of the atom would cause the disintegration of the physical universe. The atom has been split and the physical universe maintains its stability. It is the social universe the stability of which is threatened. The prevention of the disintegration of the social universe is the fateful challenge the age of atomic energy throws down to our generation." 32/

For its part, industry was then still moved by the idea of profit maximization, and had a limited notion of the social role it could or should play. It could not justify expenditures to its stockholders or creditors lying outside a narrow realm of business interest. Secondly, it was part and parcel of the tribal elder management scheme by which decisions had traditionally been made in our society. When government

issued a technological edict, industry's role was to find a suitably profitable manner of addressing the demand contained in the edict. The more recent and welling calls for "education of the public" on the part of scientists and technologists about their activities, their missions and their subject matters, all reveal a recognition of the educational failings which are now seen not only to be basic threats undercutting technological advance, but causal factors in a number of current environmentally-oriented debates. [33/] For example, Duncan [34/] points to the real difference between public confusion on issues where experts agree (the public follows its own dictates) and on issues in which experts disagree (the public follows some "relevant" interest group's position and discredits contrary statements). [35/]

The public would have been educated however, at least sufficiently to preclude polarization of attitudes on environmental matters, had the structure of elite groupings in society not itself been in turmoil. Elsewhere [36/] I have argued that after several hundred years of dominance within the scientific field of the ideas of the physical sciences, those of the biological and social sciences are beginning to assert themselves. [37/]

This shift in the structure of societal attitudes is independent of, but interacts with contemporary debates, using the problem areas therein as platforms for discussion of the underlying paradigm issues. These disputes affect all sectors of society, especially business with its sensitivity to market factors. The need for a wider variety of expertise in the policy making process is a conclusion reached by

numerous authors, including a number in the business field. For example, Wills says:

> "Business can and it should take a positive role, along with government and unions, to see that technology is planned and deployed in order to meet defined social objectives. 38/

And a government staff member asserts:

> "The fact that applied science permeates the entire fabric of society argues against a single assessment institution and argues for the development of assessment mechanisms in a wide variety of government agencies, universities, nonprofit organizations and commercial firms...Technology assessment is the final step in a long sequence that could be termed the socialization of science." 39/

General Motors now has a Societal Analysis department consisting of sociologists, psychologists, political scientists, economists and operations researchers, and GE considered it worth its while to experiment with having a research sociologist on its staff, too. Industry in this complex environment, finds itself barraged with ideas and lacking in justifiable bases for undertaking what many would term "appropriate" action. The paradigm revision is not complete, and probably will not be in our lifetimes. Competing groups will continue to advise opposing courses of action, debate will intensify, and confusion will reign.

There is a way out, however, especially for those of you here today who are committed to obtaining environmental goals. You can learn, as many of you have been doing, more about the constraints operating upon the industrial sector which impede the quickness of its response to what seems reasonable demands. Given the fairly heavy emphasis on "corporate

responsibility" and "open government" that pertains today, social scientists should find the going easier than ever before, although it will still require hard work. [40] And it will require some change in attitudes comparable to those in the earlier centuries when manual labor and then mining as "applied" efforts were denigrated. Many of us have a doubtful attitude toward applied sociology, although that is changing [41]--perhaps in response to economic conditions, for employment is a powerful motivator.

But applied sociological work is a natural laboratory where real amelioration of social problems can begin to take shape. Richard Feynman once asked what the role of scientific culture should be in modern society. Social scientists now have the opportunity to become integral parts of wider aspects of that scientific culture, and to help direct its course from within. [42] Unfortunately, we are not fully participating members of the scientific culture because we have excluded ourselves (as well as having been excluded) from one of the largest sectors of society in which this scientific culture operates: industry. [43] As Florian Znaniecki points out, a person's participation in a knowledge system often depends upon his or her participation in some social system. [44] Ironically, at the conference on science and society at which Feynman spoke, as well as at one more recently sponsored by EPRI, social scientists were notable by their relative absence. Some were absent because they could not attend. Others were simply not part of that social system, and so they could not participate in the "knowledge" which that conference legitimated. We do not yet have that "participatory" technology" [45] which can counteract technological alienation.

But we can approach it by endeavoring to play a cooperative role both within organizations and in academia. Sociological theory has skirted some of the real issues involved in social change by focusing either on Marxist critiques of the corporation or on organizational theory divorced in the main from organizational practice because we have not been part of that practice and have therefore not always understood what was going on. If we seek to inform ourselves, we will find a veritable gold mine of research and thesis topics in the industrial sector that industry will be happy to fund if they can be justified to those responsible for allocating the monies. These projects do not have to suffer the "bias of the auspices" either in their formulation, their results, or their availability, if by our own actions we do not create a self-fulfilling prophecy. There are plenty of consulting firms available to do that, and it's my reading of the situation that corporations know they need the hard truth in order to intelligently plan their futures and maximize their profits. For example, the group with which I work outlined a much more pessimistic growth scenario than one business sector would once have cared to hear. Because they had built up an operating pattern dependent upon the old view, they were tough critics, but in the end they saw where the chips lay, and they began to revise their strategy. Similarly, when we had an interchange with some very critical environmentalists, they were surprised not only at our intellectual position, which they shared to a large extent, but with our plans made in light of those forecasts. To a certain extent, the company had been stereotyped, too.

A key issue for policy making, it seems to me, is to explore the effects of different kinds of energy conservation measures on the many segments of society. There has been a lot of oratory, but the careful and detailed studies upon which scientific knowledge rests, have not been undertaken. It's almost as if nobody wants to know the answer. Policy proposals appear daily in the literature, but outside of the support they receive from some modeler's activities, I'm not aware of any empirical basis for many of the assumptions underlying such proposals, nor am I aware of any particularly sociological contributions to such efforts. It seems to me that before we embark on the year 2001, we ought to have a better notion of who we are first and then consider where we're going.

I began by saying that we've heard the environment-technology debate before, and I tried to show how, regardless of time, technology is affected by various forces within society which have been given insufficient attention. Then I moved to a specific problem area and tried to illustrate how its outcome was influenced by the operation of some of these forces, and how realistic claims on technology would have to take these into account in designing social systems that would minimize their impact. Finally, I closed by coming back to one of the hopeful aspects of the debate: the fact that as an implicit paradigm shifting phenomenon, it offered the opportunity to social scientists to help in rectifying the situation. I hope that some of you may be inspired to undertake the challenge.

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   Environmental concerns appeared in literature long before they were identified as "issues" and brought before the public. See: R. E. Lowrey: THE ENVIRONMENT AND LITERATURE: A SELECTIVE, ANNOTATED BIBLIOGRAPHY OF LITERATURE RELEVANT TO ENVIRONMENT STUDIES. Council of Planning Librarians Bibliography 1441, January 1978.

   What has been surprising in this progression is the nature of the attention paid to the social components of the tradeoffs between environmental and technological issues. Roger Evered has performed a content analysis of periodical literature, searching for measures of interest in the future. He finds a cyclical pattern, our present period being a trough. See his: "Interest in the Future: A Search for Usable Measures," FUTURES 9 (4), August 1977, pp. 285-302.

   We can look at the historical record of social movements in a similar fashion. The Great Awakening of 1730-40 was a reaction against the increasing secularization of society and against the corporate and materialistic nature of the principal churches of American society. (For an analysis of the development of this spirit, see: T. C. Cochrane and W. Miller: THE AGE OF ENTERPRISE. NY: Harper Torchbooks, 1961. A contemporary view is given by R. Nisbet in: "Capitalism and the Intellectuals," REGULATION, Nov-Dec 1977, pp. 38-39).

   The period 1780-90 saw numerous small rebellions against inequities in taxation and land policy. 1830-50 saw the Age of Reform institute utopian communities and Protestant evangelical movements ally against what critics at the time believed to be the nation's "true religion: pursuit of the dollar." Following the hiatus after the Civil War, as righteous an expression of hidden agendas (agrarian versus industrial interests) as ever existed in our history, we had the first frankly environmental call to arms in the conservation movement of the 1890's. The frontier was officially closed and agrarian interests were unofficially defeated by the hand-in-hand march of urbanization and industrialization that exchanged southern Europeans for slaves. In 1906 the Department of Interior withdrew 148 million acres of forest lands, 80 million acres of mineral lands and 1.5 million acres of water power sites from the public domain. Again, in the 1930's following a decade of pro-business attitudes in government (Harding pleaded for "less government in business and more business in government") followed by a depression of unprecedented proportions, the U.S. saw an environmental movement pragmatically oriented towards improving farming practices, land management, and undertaking reforestation projects.

   It is interesting to speculate on the conjunction between popular acceptance of fears about resource scarcity and science professionals' concern with the

status of their fields. Lord Kelvin thought in 1894 that not much of substance remained to be revealed in science. Bentley Glass applied the argument in 1971 that a casual perusal of scientific thought would demonstrate that by the nature of its exponentiation, the end was in view. If one examines population figures for the last 1000 years, one can also see an exponential growth pattern that suggests that leveling off might have occurred in 1750. Contemporary demographers are beginning to see an empirical end in declining birth rates, but that has happened before, too. See the interchange between R. B. Fink, Bentley Glass, G. P. Meade and Rudolf Steinberger on "Less than the Golden Future," SCIENCE 172, 9 April 1971, pp. 111-112. The interested reader might want to consult the following:

C. S. Griffin : THE FERMENT OF REFORM, 1830-60. NY: T. Y. Crowell, 1967.

L. Marx: THE MACHINE IN THE GARDEN: TECHNOLOGY AND THE PASTORAL IDEAL IN AMERICA. NY: Oxford Univ. Press, 1964.

L. Marx: "American Institutions and Ecological Ideals," SCIENCE 170, 1970, 945-52.

A. Mazur: "Opposition to Technological Innovation," MINERVA 8, 1975, 58-81.

T. Merton: "The Wild Places," in I. L. Horowitz, ed., THE TROUBLED CONSCIENCE: AMERICAN SOCIAL ISSUES. Santa Barbara: The Center for the Study of Democratic Institutions, 1971, pp. 354-64.

L. W. Moncrief: "The Cultural Basis for Our Environmental Crisis," SCIENCE 170, 30 October 1970, 508-12.

H. T. Odum: ENVIRONMENT, POWER AND SOCIETY. NY: Wiley Interscience, 1971.

D. Robbins and R. Johnston: "The Role of Cognitive and Occupational Differentiation in Scientific Controversies," SOCIAL STUDIES OF SCIENCE 6 (3-4), Sept. 1976, 349-68.

4. J. D. McCarthy and M. N. Zald: THE TREND OF SOCIAL MOVEMENTS IN AMERICA: PROFESSIONALIZATION AND RESOURCE MOBILIZATION. Morristown, NJ: General Learning Press, 1973.

5. In medieval times, technology was regulated quite strictly, not only by craft guilds, but by governments as well. Astrom points out how in the 17th century, Sweden prohibited the use of any but the one-blade sawmill for over 100 years. Officials feared that resource scarcity would result from the use of the Dutch fine blade saw which was six times as efficient. (Astrom, S. E.: Foreign Trade and Forest Use in Northeastern Europe 1660-1860 in A. Maczak and W. N. Parker, eds., Natural Resources in European History. Washington, DC. RFF 1978, pp. 43-64). It was resource scarcity in the context of existing technology which forced the change from bronze to iron and brass artillery during the period 1410-1450, (ibid.), a shift of enormous social consequence when one considers the uses to which steel technology, arising out of that of iron, was later put. A further snowball effect occurred when forest depletion in England caused coal to be substituted for wood in furnaces, itself permitting a greatly increased application of iron-mongering. (John U. Nef: An Early Energy Crisis and Its Consequences. SCIENTIFIC AMERICAN, 1977, pp. 140-151.)

6. J. U. Nef: An Early Energy Crisis and Its Consequences. SCIENTIFIC AMERICAN, 1977, pp. 140-151.

7. T. Garrett: Illustrations of technological forecasting for R&D evaluations. pp. 231-41 in G. Wills et al: TECHNOLOGICAL FORECASTING AND CORPORATE STRATEGY. NY: Elsevier, 1969. Although we are fond of estimating resources - indeed, a number of multimillion dollar projects have as their goal the precise estimation of the nation's resources "to meet national needs" - it is

not entirely true that resources are immutable entities whose quantities can be measured and/or consumed at specific rates, and which thereafter are "depleted." Technology and resources exist symbiotically in a matrix of ideas. Much of the angst in the current debate arises from a failure to take into account the resource-producing nature of technology in its role as objectification of ideas.

8. We are more familiar with the demands that social forces exert upon technology. For example, the "ideology of technology," that attitude of strongly pro-technology sentiment, existed in the American mind well before the term "technology" came into popular use in 1829. The idea of democracy itself even became consciously associated with progress in the applied sciences (Hugo A. Meier: The Ideology of Technology in E. T. Layton, ed.: TECHNOLOGY AND SOCIAL CHANGE IN AMERICA. NY: Harper & Row, 1973, pp. 80-97) serving as an enormous spur to development in the 19th century.

9. It is often surprising to people of highly industrialized nations that members of vastly less developed cultures have survival rates comparable to our own, it being assumed that life in nature would automatically be "nasty, brutish and short."

10. K. Azumi: Environmental Needs, Resources, and Agents in K. Azumi and J. Hage, eds., ORGANIZATIONAL SYSTEMS. Lexington, MA: D. C. Heath, 1972, p. 91.

11. William F. Ogburn, discussing the implications of the atomic age at a Chicago Round Table discussion with Robert Maynard Hutchins and R. G. Gustavson on August 12, 1945, pointed out that his studies of invention and social change revealed that "all inventions of the past that I have studied have been resisted." Moreover, he disputed that such resistance was due to such factors as the actual effects on employment that appeared implicit in most technological change. "Most inventions produce technological unemployment only temporarily...I have calculated, for instance, that only 15% of the depression of the 1930's was technological."

12. For example, see H. Henderson: The End of Flat Earth Economies and the Transition to Renewable Resource Societies. ALTERNATIVES: PERSPECTIVES ON SOCIETY AND ENVIRONMENT 8(1), Winter 1978, 15-22; Arthur Barber: Toward World Corporate Structures. CURRENT 102, December 1968, 61-64; William H. Boyer: ALTERNATIVE FUTURES: DESIGNS FOR SOCIAL CHANGE. Dubuque, Iowa: Kendall/Hunt, 1975; Eugene S. Schwartz: OVERSKILL: TECHNOLOGY AND THE MYTH OF EFFICIENCY. NY: A. A. Knopf, 1964; Kenneth E. F. Watt et al: THE UNSTEADY STATE. Honolulu: University of Hawaii Press, 1977. While some of these calls for action are less considered than others from the social point of view, some critics are quite thoughtful of the implications. For example, see M. E. Kraft: "Political Change and the Sustainable Society," in D. C. Pirages, ed., THE SUSTAINABLE SOCIETY: IMPLICATIONS FOR LIMITED GROWTH. NY: Praeger, 1977. Kraft realizes that we should rightly be skeptical of first-generation solutions to environmental problems: not only do we not know the causes of our ecological difficulties, we do not know the consequences of adopting the highly touted reforms. On this aspect, William Nierenberg (Director of Scripps Oceanographic Institute) pointed out that some of our assumptions about life cycling on earth are incorrect. Some natural cycles are longer than the human life span, and consequently, people may "observe" a decline in a particular resource which is part of a "normal" fluctuation as revealed by geological core sampling.

13. See G. Wills et al: TECHNOLOGICAL FORECASTING AND CORPORATE STRATEGY. NY: Elsevier, 1969, p. 5.

14. DICTIONARY OF INVENTIONS AND DISCOVERIES. London: Muller, 1966.

15. If we examine the histories of some previous high technologies, environmentally "benign" and therefore likely to arouse little public opposition and basically interfacing the existing technostructure in a satisfactory manner, we would think their development should have proceeded smoothly. But scientific breakthroughs, interacting with components of the social and institutional matrix, have their own rate of development. It took television some 55 years, from 1884 to 1939 - although even then, the public did not obtain television until the mid-fifties - to become a commercial product. Zippers took some 30 years to reach the market in 1913. Penicillin required 15 years of intensive effort, assisted by government funding during the war effort, before its introduction in 1943. Xerography's debut in 1950 after 15 years of work was hardly noticeable, although it came to dominate the market in copying processes and indeed, spurred a vast array of social changes, including the revision of copyright laws. [L. Adler: Time Lag in New Product Development. J. MARKETING 30, 1966, pp. 17-21)

    These technologies had very little normative component to them; that is, they were not objectives established to fulfill societal needs by a target date. We did try something like that with the "war against cancer," only to find that progress can rarely be mandated by either good will, intensive effort, or extensive funding. And, of course, the normative element in the nuclear decision is a key to its rejection by critics.

16. INVENTING THE FUTURE. NY: Penguin Press, 1964

17. A. Gandara: ELECTRIC UTILITY DECISION MAKING AND THE NUCLEAR OPTION. Rand 2148, June 1977, p. 4.

18. Editors of Pocket Books: THE ATOMIC AGE OPENS. August, 1945, p. 191.

19. W. Allen: NUCLEAR REACTORS FOR GENERATING ELECTRICITY: US DEVELOPMENT FROM 1946-63. Rand Report 2116, June 1977. The National Security Council ruled in 1953 that early development of nuclear power was essential for the U.S. to retain its lead in the atomic field. Both Great Britain and the USSR threatened that lead. (R. Perry et al: DEVELOPMENT AND COMMERCIALIZATION OF THE LIGHT WATER REACTOR, 1946-76. Rand 2180, June 1977.

20. These difficulties may arise because a nation lacks relevant expertise, or as is more often coming to be the case now, because social values mitigate against its development and exploitation. In this context, it should be remembered that innovation requires a great deal of public and private support that is steady, consistent, predictable and relatively long term. Failing this support, technologies wither on the vine too. See: C. P. Haskins: "Public and Private Science," AMERICAN SCIENTIST 64(5), 1976, 493-99. The slow development of the space shuttle attested to the lack of infrastructure available for Skylab.

21. Gandara, op cit., p. viii.

22. This managerial ethos is still epitomized in the manner in which the nuclear industry lobbies government. Daniel Dreyfus, staff director of the Senate Committee on Energy & Natural Resources said in an interview in NUCLEAR INDUSTRY (May 1979, pp. 29-30):

    "Like the oil industry, the nuclear business continues to do business the old way - by having a few prominent people contact a few friends in Congress, tell them what's important about a bill, and hope they do their lobbying for them. This worked before...professionalized public interest groups arose."

It worked because there was no intelligent competition. However, today, anti-nuclear groups talk to hundreds of junior members and staff aides, making them feel important. At voting time, committee members are working from a paper written by their staff people who feel comfortable with the anti-nuclear people. "The answer," Dreyfus continued, "is to produce position papers that the average bright young law school graduate can understand."

23. R. Jungk: THE NEW TYRANNY: HOW NUCLEAR POWER ENSLAVES US. NY: Grosset and Dunlap, 1979.

24. J. Cagnetta, personal communication.

25. C. H. Danhof: Assessment Information Systems, in R. G. Kasper, ed., TECHNOLOGY ASSESSMENT: UNDERSTANDING THE SOCIAL CONSEQUENCES OF TECHNOLOGICAL APPLICATIONS. NY: Praeger, 1972. Danhof suggests that one consult A. Schiff: FIRE AND WATER: SCIENTIFIC HERESY IN THE FOREST SERVICE. Cambridge, MA: Harvard University Press, 1962. Also see: I. C. Bupp and J-C Derian: LIGHT WATER: HOW THE NUCLEAR DREAM DISSOLVED. NY: Basic Books, 1978.

26. M. E. Ames: OUTCOME UNCERTAIN: SCIENCE AND THE POLITICAL PROCESS. Washington, DC:Communications Press, 1978, p. 11.

27. Nelson Foote pointed out that the corporation's new role as technology advanced would be to provide information to customers to compensate for institutional lags in the system. By extrapolation, we can see that as innovation progresses, the information service will have to go "on line" sooner and sooner relative to the introduction date of the innovation to compensate for the lag forces. See his "The Autonomy of the Consumer" in L. H. Clark, ed., CONSUMER BEHAVIOR: THE DYNAMICS OF CONSUMER REACTIONS. NY: NYU Press, 1955.

28. Perry et al, op cit., p. 35.

29. See: J. B. Quinn: "Technological Strategies for Industrial Companies," in G. Wills et al., TECHNOLOGICAL FORECASTING AND CORPORATE STRATEGY. NY: Elsevier, 1969, pp. 50-73.

30. The coal industry also responded to the threat in another traditional way: in 1977 six coal vendors were charged with price fixing during the period 1961-74 and pleaded no contest. (Gandara, p. 56)

31. Belatedly, this situation is being rectified. See: C. Holden: "Science Show for Children Being Developed for TV," SCIENCE 202, 17 Nov. 1978, pp. 730-1.

32. Both quotes from The Editors of Pocket Books: THE ATOMIC AGE OPENS. NY: Pocket Books, August 1945.

33. Others have extended this analysis to include the popular literature. For example, June Goodfield asserts that science was driven inward in the 1800's due to a mixture of its own ineptness in proselytizing and society's ill humor over the ethical questions science raised. The resulting lack of science in literature thus failed to provide role models for potential aspirants, who, being limited to scientific papers (which misrepresent the actual reasoning processes underlying scientific work), saw a vision of science which was even further removed from reality. See her: "Humanity in Science: a Perspective and a Plea," SCIENCE 198, 11 Nov. 1977, pp. 580-85.

34. O. D. Duncan: "Sociologists Should Reconsider Nuclear Energy," SOCIAL FORCES 57(1), Sept. 1978, pp. 1-22.

35. Also see T. R. la Porte and D. Metlay: "Technology Observed: Attitudes of a Wary Public." SCIENCE 188, 11 April 1974, pp. 121-27; and S. Krause et al: "Mass Media and the Fallout Controversy," PUBLIC OPINION QUARTERLY 27, 1963, 191-205.

36. A. R. Tiemann: "Environmentalism as a Social Movement," Graduate seminar of the Sociology Department, SUNY-Albany, December 1978.

37. Critical activity may be divided into roughly three areas: (1) historical perspectives on science - the "two cultures" concept of C. P. Snow, and studies on the social structure of science; (2) critiques of the dominant perspective as to its assumptions and methodology; and (3) outright paradigm revising activity such as that of Prigogine. Examples of activities in the first category are the work of B. C. Griffith and N. C. Mullins on "invisible colleges" in science ("Coherent Social Groups in Scientific Change: 'Invisible Colleges' may be Consistent throughout Science," SCIENCE 177, 15 Sept. 1972, 959-64). Such critical activity would inevitably provide food for dissident thought. C. P. Snow recognized this development in his THE TWO CULTURES AND THE SCIENTIFIC REVOLUTION (Cambridge Univ. Press, 1959). More recently the plea by a chemist for "Sensuous-Intellectual Complementarity in Science" (T. R. Blackburn, in SCIENCE 172, 4 June 1971, 1003-8) provides direction for the analytic activity. Blackburn claims that "rationality" is not a property of any one viewpoint. Rather, we must enlarge our frame of scientific reference to include both subjective and objective models since neither is complete in itself. Blackburn's ideas are carried somewhat further by P. Snyder in his TOWARD ONE SCIENCE: THE CONVERGENCE OF TRADITIONS. (St. Martin's Press, 1978). As Whitley argues (R. Whitley: SOCIAL PROCESSES OF SCIENTIFIC DEVELOPMENT. Boston: Routledge & Kegan Paul, 1974), Copernican rationality, which resonated particularly well with increasing industrialization, has lost its raison d'etre as industrialization has become complete. Along with rationality went the natural sciences, and as Kuhn showed how "proper" science contains a large fictive element, we increasingly become confused about understanding science as a culturally embedded phenomenon. The environmental expression of these ideas has been aired in W. P. Webb's familiar extension of the Turner Thesis (that the closing of the American frontier was related to our shift to an "environmental" orientation." (W. P. Webb: "The Frontier and the 400 Year Boom," in G. R. Taylor, ed., THE TURNER THESIS. Boston: D. C. Heath, 1956). More critical authors have phrased it differently. See: B. Weisberg: BEYOND REPAIR: THE ECOLOGY OF CAPITALISM. Boston: Beacon Press, 1971. For further reading on this point, see: H. Brooks: Are Scientists Obsolete, What is Happening to Their Social Role, and Where are the Future Markets for Their Services? SCIENCE 186, 8 Nov. 1974, pp. 501-8; M. S. Baram: Social Control of Science and Technology. SCIENCE 172, 7 May 1971, pp. 535-39; V. Taylor: Subjectivity and Science: a Correspondence about Belief. TECHNOLOGY REVIEW, Feb. 1977, pp. 49-57; K. S. Pitzer: Science and Society: Some Policy Changes are Needed. SCIENCE 172, 16 April 1971, pp. 223-26; Francois Hetman: "Social Assessment of Technology and Some of Its International Aspects." Technological Forecasting and Social Change 11, 1978, pp. 303-313.

Critiques of the dominant view decry its one-dimensionality, its failure to take a broad enough base into account, and its methodological limitations. Ellul's attack on "technique" as the technological imperative by which invention becomes the mother of necessity (I. Hoos: "The Mystique of Technique in Energy Policy," presented at CRD, June 1978) is echoed in Ehrlich, Commoner, Carson, Jungk, Gabor, and many others. These writers are picking up the action cues in the historical analyses. We have been so enamoured of our physical science and its technology that we have sought inappropriately to

adapt its elements to all our other problem areas as well. As Layton remarks, because technological change is mainly guided by private individuals acting for profit, social effects (except narrow economic ones) are excluded from decision-making. Hence, the adverse results of technology are not simply a matter of accident. (E. T. Layton: TECHNOLOGY AND SOCIAL CHANGE IN AMERICA. NY: Harper & Row, 1973). In obeisance to its hegemony, we have, for instance, tried to rationalize its methodology in spite of the differences between physical laws and policy making activities in the social problem arena. However, operations research, systems analysis and mathematical modeling have all been attacked on the reasonable grounds that what they attempt to do by way of providing answers to social problems, is not matched either to social science knowledge, or to the problems it addresses. See: I. R. Hoos: SYSTEMS ANALYSIS IN PUBLIC POLICY: A CRITIQUE. Berkeley: Univ. Calif. Press, 1972; D. Berlinski: ON SYSTEMS ANALYSIS. Cambridge: MIT Press, 1976; D. N. Michael: "Technology Assessment in an Emerging World," TECHNOLOGICAL FORECASTING AND SOCIAL CHANGE 11, 1978, pp. 189-95.

An excellent critique of modeling is given by J. P. Martino and R. C. Lenz in "Barriers to the Use of Policy Relevant Information by Decision Makers," TECHNOLOGICAL FORECASTING AND SOCIAL CHANGE 10, 1977, pp 381-90. For a specific example in the environmental area, see D. Medford: ENVIRONMENTAL HARASSMENT OR TECHNOLOGY ASSESSMENT. NY: Elsevier, 1973.

Holroyd sees a shift in economic theory, affecting business and its organization in society. He claims that structuralist methods are useful where the system is continuous, but that discontinuous changes are identifiable as paradigm shifts which portend changes in other elements in the system. See his "Change and Discontinuity: Forecasting for the 1980's," FUTURES, Feb. 1978, pp. 31-43. In a similar vein, Tibor Scitovsky (THE JOYLESS ECONOMY. London: Oxford Univ. Press, 1976) argues that economics can't explain why students revolted in the 1960's after per capita real income in the U.S. had been rising 62% over 25 years. On the contrary, Scitovsky posted an "irrational" response analogous to Simon and Gagnon's "anomie of affluence" hypothesis in which comforts lose their appeal as they become more easily attainable. (See: W. Simon and J. H. Gagnon: "The Anomie of Affluence: a Post-Mertonian Conception. Amer. Journal of Sociology 82(2), Sept. 1976, pp. 356-78.)

Leading naturally from the first two critical endeavors and interacting with them, the most significant of the paradigm revising activities is, of course, the development of new scientific ideas. It is particularly interesting that progress in this sphere should strike at the heart of what some see as the technological trap: the limit placed by thermodynamic theory on the possibility of a technological "fix," and that it should derive from the perspective most active in contesting the natural sciences' dominance in the scientific world: biology. See: Charles Crussard: "A New Thermodynamics of Growth," RESEARCH MANAGEMENT 16(6), November 1973, pp 13-16. Crussard's position echoes that of Prigogine, in his postulation of the evolution of complexity through amplifications in fluctuations past a point of no return. However, Crussard's view of the outcome of this process environmentally is positive, while that of Prigogine is negative. (Ilya Prigogine et al: Long Term Trends and the Evolution of Complexity, in E. Laszlo and J. Bierman, eds., GOALS FOR MANKIND. Vol. 1: STUDIES ON THE CONCEPTUAL FOUNDATIONS. Pergamon Press, 1977, pp. 1-63.)

38. G. Wills: "The Art and Management of Technological Forecasting," in G. Wills et al: TECHNOLOGICAL FORECASTING AND CORPORATE STRATEGY. NY: Elsevier, 1969, pp. 3-16.

39. R. A. Carpenter: "Technology Assessment and the Congress," in R. G. Kasper, ed., TECHNOLOGY ASSESSMENT: UNDERSTANDING THE SOCIAL CONSEQUENCES OF TECHNOLOGICAL APPLICATIONS. NY: Praeger, 1972, pp. 29-38.

40. There have been a number of articles in the popular commercial press, such as BUSINESS WEEK, on corporate responsibility towards the public and its employees. This movement is, like environmentalism, a world-wide phenomenon. Also see: L. E. Preston, ed.: RESEARCH IN CORPORATE SOCIAL PERFORMANCE AND POLICY. Jai Press, 1978.

41. Sociologists' doubtful attitudes toward the engineering component of the "social engineering" implicit in applied sociology is manifest in the way in which engineering became established as a profession. As Rudoff and Lucken point out, both specialization and bureaucratization served to divorce engineering practice from its idealistic base. There is little reason to repeat this mistake in promoting applied sociology now that we are aware of its genesis. (See: A. Rudoff and D. Lucken: "The Engineer and His Work: a Sociological Perspective," SCIENCE 172, 18 June 1971, 1103-8.)

42. R. P. Feynman: What is and What should be the Role of Scientific Culture in Modern Society? NUOVO CIMENTO, Supplemento 4, 1966.

43. "What do you DO?" is the question people most often ask me, regardless of whether their background is in the physical sciences, the humanities, or the social sciences. This lack of conceptualization of social science work in the real world, say in an industrial research setting, is one of the stumbling blocks to the effective use of social science skills outside academia. It attests to our practical "irrelevance" in the minds of many observers, an attitude we must strive to change through applying ourselves to practical problems and gaining a track record. But it is enormously exciting to be making social innovation, inventing a career. This situation is slowly changing as social scientists become better integrated into scientific networks. For example, see C. Holden: ABASS: Social Sciences Carving a Niche at the Academy," SCIENCE 199, 17 March 1978, pp. 1183-7.

44. THE SOCIAL ROLE OF THE MAN OF KNOWLEDGE. NY: Columbia Univ. Press, 1940.

45. J. D. Carroll in SCIENCE 171, 19 Feb. 1971, pp. 647-53.